Design Procedures and Field Monitoring of Submerged Barbs for Streambank Protection

tech transfer summary

Computational hydrodynamic models can assist in decisions regarding the optimal dimensions and distances between barbs.

Objectives

The main objective of this study was to evaluate the hydraulic performance of riprap submerged barbs in controlling bank erosion at the Southern part of the Raccoon River upstream U.S. Highway 169 Bridge utilizing the commercially available hydrodynamic model FESWMS (developed by the FHWA) and field monitoring.

Problem Statement

The North abutment of the U.S. Highway 169 Bridge, located on the Raccoon River central Iowa, is threatened by excessive bank erosion due to the formation and movement of a meander bend located upstream of the bridge. The meander bend (Figure 1) once located approximately 1800 ft upstream of the North bridge abutment has translated downstream to within 450 ft of the bridge. The observed bank erosion appears to be accelerating as the bridge acts as a control structure not allowing the downstream portion of the reach to adjust to changes upstream. The Iowa Department of Transportation (IDOT) and Bridge Engineer Mr. David Claman decided that if allowed to continue unregulated, the bank erosion could threatened to wash away the North bridge abutment thereby threatening the bridge's overall structural integrity. To mitigate this problem, the IDOT proposed to install riprap submerged barbs (Figure 2) to increase the conveyance along the center of the stream to reduce the erosive force exerted on the bank by the river.

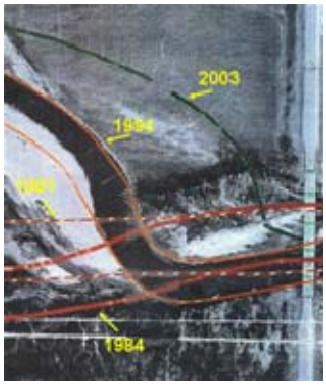

Figure 1. Observed movement of Raccoon River Channel Upstream of the U.S. Highway 169 Bridge. The various color bands represent the observed location of the streambanks during the year indicated. U.S. Highway 169 can be seen running North and South along the right hand side of the photo. Flow is from left to right.

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RESEARCH PROJECT TITLE
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SPONSORS
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IIHR's historic C. Maxwell Stanley Hydraulics Laboratory was dedicated as a National Historic Civil Engineering Landmark in 2005, placing it among the major structures of national importance to the engineering profession. The mission of the IIHR is to conduct research in water resources and environmental engineering.

Figure 2. Constructed bendway barbs looking upstream from the U.S. Highway 169 Bridge.

Research Description

For this project, a multifaceted approach was required that involve:

1. collection and analysis of available historic and current data in the region of interest at the Raccoon River;
2. performing of field measurements (Figure 3) for model calibration and verification. This includes flow and bed topography mapping for the region of interest; and
3. using of the hydrodynamic model FESWMS (Figure 4) to simulate various flow conditions with and without the barbs to evaluate their performance in controlling bank erosion. The model has wetting and drying capabilities suitable for simulating flows around barbs.

Figure 3. Field measurements. Left to the bottom: deposition area generated between barbs.

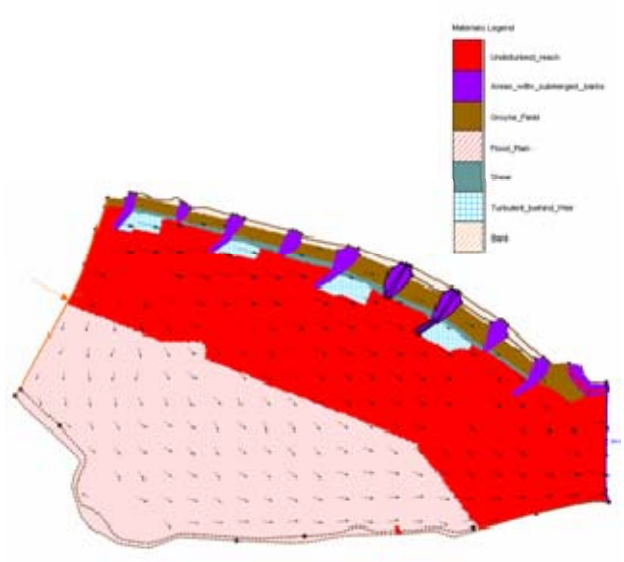

Figure 4. Model calibration.

Key Findings

- The hydrodynamic model FESWMS results showed that the proposed IDOT barbs design was able to control bank erosion for most of the high flow events by reducing velocity magnitude along the channel bank and increasing conveyance in the center of the channel. This design was proven to be reliable for mid-size rivers having similar characteristics like the Raccoon River.
- The produced velocities and applied shear stress along the bank have been dropped to fall within the recommended values for channel stability design.
- Surveys obtained by sonar and the presence of vegetation indicate that new material has been added at the bank toes. About 2 ft of new material was deposited in the area located between the barbs since their construction.
- The barbs created a shallow water habitat condition favorable for fish population by providing higher variability in bed topography forming resting pools, flow shade on the leeward side of the structure, and separation of bed substrate due to different flow conditions.
- Another notable environmental benefit of the barbs is directly related to the induced scour-hole at the toe. Significant increases in fish size, numbers, biomass, and number of species was observed following the increase of the barbs scour-hole volume.